Evaluation of sludge from paper recycling as bedding material for broilers

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ABSTRACT Several materials have been used as bedding substrates in broiler production. In this work, the sludge from paper recycling was tested for its potential use as litter material and was compared with wood shavings. Moisture content, apparent density, and water-holding capacity were measured and characterized in both materials. Later, 192 male broiler chickens were distributed among 16 experimental pens, 8 of which contained wood shavings as bedding material and 8 of which contained the sludge. Growth rate, consumption, tonic immobility, gait score, breast lesions, foot pad dermatitis, hock burn, tibial dyschondroplasia, and metatarsal thickness were determined in the birds. Although the moisture content of the sludge was high, it decreased strongly after 7 d of drying, reaching lower values than those of wood shavings. In general, few differences were found between the materials in terms of bird performance and welfare and only the incidence of hock burn was higher in the sludge than in the wood shavings. Although further research is needed, sludge from paper recycling is a possible alternative to traditional bedding materials because it achieves most of the requirements for broiler bedding materials and does not show negative effects on the birds.

Key words: broiler, bedding material, leg disorder, recycled paper, welfare

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INTRODUCTION

In poultry production, wood shavings and rice hulls have commonly been used as bedding materials. Moreover, attempts have been made to use and test several types of material for litter such as refined gypsum, cotton waste (Grimes et al., 2006), recycled paper chips from waste newspapers (Lien et al., 1992; Santiago et al., 2006), pelleted newspaper (Frame et al., 2002), kenaf core (Brake et al., 1993), particleboard residues (Hester et al., 1997), leaves (Willis et al., 1997), sand (Arnould et al., 2004), hazelnut husks or wheat stalks (Sarica and Cam, 2000), rice hull ashes (Chamblee and Yeatman, 2003), coffee husk (Ortiz et al., 2006), coir dust (Swain and Sundaram, 2000), straw (Al Homidan and Robertson, 2003), feathers (Gunnarsson et al., 2000), and peat (Petherick and Duncan, 1989). The use of any of these substrates most often depends on the availability and economics in each area and at each moment.

Several factors help to determine whether a material is a good bedding source. In general, it has to be very absorbent and have a reasonable drying time and must not be toxic to poultry or poultry farmers (Grimes et al., 2006). It also has to meet hygienic requirements and guarantee that ammonia concentration does not exceed certain levels throughout the productive cycle, among other things (Worley et al., 1999). In addition, bedding type can significantly affect carcass quality and growth performance of broilers (Malone et al., 1983), so the materials have to be properly tested.

Sludge from paper deinking is produced during the paper recycling process. The final destination of this sludge is usually the landfill site, but some new uses are being tested, such as use in the pottery industry, for composting, for agricultural purposes, or for energy. In addition, the sludge might have farming uses, such as use as bedding material. The aim of this work was to assess sludge from the deinking of recycling paper as bedding material for broilers throughout the productive cycle, attending to both productive and welfare parameters.

MATERIALS AND METHODS

Bedding Materials

The tested material came from the sludge of the deinking process of the paper mill industry (hereafter called paper residue). These residues comprise 30% cellulose (a highly porous material of vegetable origin), filler substances such as kaolin and calcium carbonate, a small portion of organic compounds and heavy metals, and approximately 40% water. Before the experiment a sample of the material was subjected to atomic

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absorption spectroscopy to evaluate its toxicity and suitability as bedding material. Analysis of heavy metals showed that the material could not be considered toxic because their levels were all below the maximum limits for undesirable substances in animal feed as presented in European Union (2002).

Both this material and wood shavings (used as control) were assessed as litter materials for broilers and their moisture content, apparent density, and water-holding capacity (**WHC**) were measured. Ten replicates of each material were analyzed in the laboratory. For the measurement of apparent density, the material was poured into a previously weighed cylinder with a volume of 79.5 cm^3. Excess material was scraped off the top of the cylinder with a straightedge and the cylinder was weighed again. Apparent density was calculated as the mass of the material divided by the volume of the cylinder. Then, the samples were prepared to determine WHC. Water was added slowly to each cylinder until saturation point was achieved (it was considered to be reached when the water started to drain from the bottom). Thereafter, each cylinder was weighed and placed on a grid on an individual container to drain for 24 h, when it was weighed again. To calculate the WHC, the volume of water held was divided by the weight of the sample.

In addition, the moisture of each material had to be monitored. Two days before the experiment started, 5 samples of each material were taken to determine their initial moisture content. After 1 d drying on the shed floor, 5 more samples were analyzed and litter moisture levels were recorded weekly. These samples were taken from 5 different areas of each pen (the 4 corners and the center, according to Bilgili et al., 1999). Litter samples were placed in plastic bags and mixed and ground before the moisture determinations were made. The methodology was adopted from AOAC (1995) to measure moisture and consisted of weighing a porcelain crucible, adding 10 g of sample, and drying it for 24 h at 105°C. Then, each sample was cooled in a desiccator and weighed again and the moisture was calculated using the following formula:

% moisture = [(weight nondried sample + container) − (weight dried sample + container)] × 100/[(weight nondried sample + container) − (weight empty container)].

Birds and Housing

A total of 192 Ross male broiler chicks were used in this study carried out in an experimental house located in Segorbe (Castellon, Spain). Chicks (1 d old) were randomly housed in 16 experimental pens in groups of 12 birds until they were 49 d old. Eight of those pens had paper residue (10 cm deep) and the other 8 pens had wood shavings (10 cm deep). The dimensions of the pens were 1 × 1.3 m, and divisions among pens permitted visual and olfactory contact among birds. All pens were in the same room, with controlled temperature and RH (according to commercial recommendations, from 31 to 20°C) and a 16 h:8 h L:D lighting regimen (except for the first 2 d, when they were under a continuous lighting regimen), with an average light intensity inside the room of 25 lx.

Birds were fed ad libitum and 3 commercial diets were used during the experimental period: starter from 1 to 21 d of age, grower from 22 to 31 d of age, and finisher from 32 to 49 d of age. All birds were individually weighed weekly and feed consumption was determined weekly. Mortality rate was recorded daily and dead chickens were also weighed.

Welfare Assessment

To evaluate the effect of the materials on broiler welfare, tonic immobility (**TI**), gait score, breast lesions, foot pad dermatitis, hock burn, tibial dyschondroplasia, and metatarsal thickness (1 cm above the spur) of the birds were assessed. Tonic immobility was assessed on d 44 in 5 birds of each pen. As soon as the broiler was caught, TI was induced in a nearby room by inverting the bird on its back with its head hanging over the edge in a U-shaped wooden cradle covered with a thick layer of cloth. The experimenter restrained the bird for 15 s by placing one hand on the sternum while covering the head with the other hand, according to the procedure described by Jones and Faure (1981). The observer sat in full view of the chicken and at a distance of about 2 m from the bird. If the bird remained immobile for 10 s after the experimenter removed his or her hands, the time until the bird showed a righting response was recorded. If the bird showed no righting response over a 15-min period, the session was ended and a maximum score of 15 min (900 s) was assigned (Stub and Vestergaard, 2001). On the contrary, if the bird righted itself in less than 10 s, it was considered that TI had not been induced and the restraint procedure was repeated. The number of inductions necessary to induce TI for at least 10 s was recorded and if TI was not induced after 5 attempts, the bird was deemed not to be susceptible and its TI duration score was 0 s (Bizeray et al., 2002).

Table 1. Apparent density and water-holding capacity of the materials (least squares means ± SEM)

Item	Paper residue	Wood shavings
Apparent density (g/cm^3)	0.393 ± 0.045	0.046 ± 0.045
Water-holding capacity (cm^3/g of substrate)	0.324 ± 0.026	5.395 ± 0.026

Table 2. Least squares means (±SEM) of parameters measured in chickens housed in the 2 substrates used as bedding

Item	Wood shavings	Paper residue	*P*-value
Final BW (kg)	2,877 ± 37.98	2,868 ± 37.98	0.8879
Conversion rate (g of feed/g of weight)	1.95 ± 0.09	1.84 ± 0.09	0.4029
Fluctuating asymmetry (cm)	0.16 ± 0.15	0.26 ± 0.15	0.6342
Tonic immobility duration (s)	186.8 ± 1.16	206.4 ± 1.16	0.6609

On d 47, gait score was assessed in 140 birds (70 of each bedding material) according to Garner et al. (2002) protocol, with scoring as follows: 0 = fluid locomotion and no degree of impairment; 1 = detectable impairment but unidentifiable abnormality; 2 = identifiable abnormality with little effect on the bird's function; 3 = abnormality that impaired function; 4 = severe impairment of function but capable of walking; and 5 = completely lame.

Finally, on d 49 the birds were slaughtered and their carcasses were taken from the slaughterhouse line after defeathering and transferred to the laboratory for assessment. Each carcass was weighed and then tibial dyschondroplasia (according to the protocol of Edwards and Veltmann, 1983), foot pad dermatitis (following Ekstrand et al., 1998), hock burn (Ekstrand et al., 1998), breast lesions (adapting Ekstrand et al., 1998), and any lesions and broken or deformed bones observed were recorded. The thickness of the tarsometatarsus (1 cm over the spur) was also measured with a digital caliper (accuracy: 0.01 mm) in both legs to evaluate fluctuating asymmetry (left minus right trait measurement). This protocol was revised and accepted by the Animal Welfare Committee of the Instituto Valenciano de Investigaciones Agrarias (Moncada, Valencia, Spain).

Statistical Analysis

Statistical analyses were performed using SAS System 9.1 software (SAS Institute, 2009). If data met the assumptions of normality and homogeneity of the error (weight, feed consumption, conversion rate, TI duration, and fluctuating asymmetry), they were analyzed with an ANOVA with the material type factor as independent variable. Tukey-Kramer adjustments were used for posthoc comparisons and logarithmic transformations for TI duration were used for ANOVA; the results in the tables are reported on the original data scale.

Data that did not meet those assumptions were analyzed with nonparametric statistics. The effect of the type of litter material on the presence of broken or deformed bones was analyzed using Fisher's exact test; in addition to this test, the rest of the variables were analyzed with the Mann-Whitney U-test. Moreover, mortality was analyzed through a chi-squared test.

RESULTS AND DISCUSSION

Bedding Materials

Apparent density and WHC of paper residue and wood shavings are presented in Table 1. A relevant difference exists between the materials according to these characteristics, and this might have several practical implications. The fact that apparent density is higher in paper residue than in wood shavings could make it more laborious to spread paper residue out on the farm when preparing sheds for arrival of the pullets and could hamper removal of the material once the productive cycle has finished. The WHC was also considerably higher in wood shavings than in the paper residue, and this could affect the litter moisture and quality. Furthermore, as Grimes et al. (2006) pointed out, inorganic materials used as bedding for broilers must have a reasonable drying time; many paper products absorb moisture but do not dry properly. For this reason, the moisture content of both litters is presented in Figure 1. Initially, when the materials were spread out on the floor of the experimental pens, their moisture was 39.41 ± 0.47 and 8.35 ± 0.66% for paper residue and wood shavings, respectively. One day later, when the 1-d-old cockerels arrived at the farm, the moisture of the paper residue was 24.24 ± 0.54% whereas the moisture of the wood shavings did not differ from the day before. At this point, a decrease was found in the moisture content of the paper residue and an increase was found in the moisture content of the wood shavings, reaching similar values as broilers grew up (Figure 1). Significant dif-

Table 3. Raw means (±SE) and Mann-Whitney test statistics (U; 1 df) comparing welfare parameters between birds housed in the 2 studied bedding materials

Item	Wood shavings	Paper residue	U	*P*-value
Attempts to get tonic immobility (n)	1.21 ± 0.07	1.25 ± 0.07	0.2385	0.6253
Hock burn	0.52 ± 0.09	1.13 ± 0.09	25.6781	<0.0001
Foot pad dermatitis	0.71 ± 0.09	0.70 ± 0.08	0.1008	0.7509
Breast lesions	0.02 ± 0.02	0.07 ± 0.02	1.0788	0.2990
Tibial dyschondroplasia	0.64 ± 0.08	0.81 ± 0.08	3.4828	0.0620
Gait score	1.81 ± 0.09	1.98 ± 0.09	3.0121	0.0826

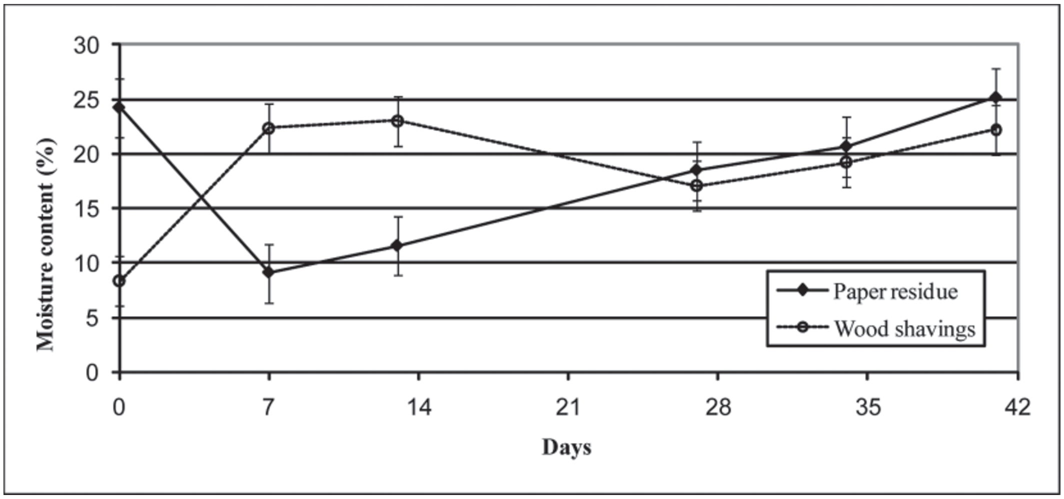

Figure 1. Evolution of the moisture content of both materials during the experiment.

ferences were present from the beginning of the experimental period until d 27. During this period, heaters were used and they may have contributed to drying the paper residue, which did not retain the water because of its low WHC. Then, from d 27 to 41 no significant differences were observed between both substrates. To the best of our knowledge, and taking into account that litter moisture content should fluctuate between 25 and 35% (California Poultry Workgroup, 1998), paper residue should not give any additional problem with litter moisture as long as it is spread out some hours before the arrival of the cockerels in order to dry. Nevertheless, the decrease in litter moisture values during the second and the third weeks (compared with wood shavings) could be interestingly assessed in further studies.

Production and Welfare Parameters

Mortality rate was 3.13% with both materials given that the same number of birds died in both treatments. The rest of the results also show very few differences between paper residue and wood shavings in the studied parameters (Tables 2 and 3). Weight, feed consumption, and conversion rate were not affected by bedding material. These findings indicate that the type of litter material had little effect on the performance of the birds, as suggested previously with different materials (Brake et al., 1993; Bilgili et al., 1999; Chamblee and Yeatman, 2003).

Regarding welfare parameters (Table 3), significant differences were found only for hock burn (63.83% of the birds housed on wood shavings had no lesion whereas only 36.56% of the birds housed on the paper residue had healthy hocks). This means that the hocks of broilers housed on paper residue had more lesions than the hocks of those housed on wood shavings, and the assessed scores were higher. This could be related to the moisture content of the materials; some paper products might result in high litter moisture and caking levels (Grimes et al., 2006). However, it was not possible to confirm this fact according to the moisture content, which was very similar in both materials (Figure 1). In addition, during the experiment it was observed that paper residue formed large stones of dried material without any type of caking (Figure 2), on which the birds rested during the whole productive cycle. This consistency of the material (jagged edges and particle size) could have affected the erosion of the hocks as Hester et al. (1997) suggested. Nevertheless, the lesions that appeared in the present study were small and no severe cases were observed.

Number of attempts to get TI, foot pad dermatitis, breast lesions, tibial dyschondroplasia, gait score, and broken bones tended to be lower in broilers housed on wood shavings but the differences were not statistically significant. Moreover, broken or deformed legs were not found in any carcass.

In general, this work suggests that the studied paper residue could be an acceptable bedding material for

Figure 2. Appearance of the material at the end of the experiment. Color version available in online PDF.

raising broilers. According to Ritz et al. (2005), bedding materials should be absorbent, lightweight, not very expensive, and nontoxic and have a high WHC and properties that minimize caking. Most of these assumptions (except for WHC) were achieved by paper residue. Moreover, we did not find any effect on welfare and productive parameters, although the effect on leg conditions should be studied carefully. Further research should therefore be carried out to clarify other aspects that were not studied in this work, such as ammonia, odor, and particulate matter emissions, to be able to consider this material as a real alternative in poultry production.

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